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The Tyranny of Concepts

CUDIE (Cumulated, Depreciated Investment Effort) Is *Not* Capital

Lant Pritchett

Using the word *capital* to represent two different concepts is not such a problem when government is responsible for only a small fraction of national investment and is reasonably effective (as in the United States). But when government is a major investor and is ineffective, the gap between capital and "cumulative, depreciated investment effort" (CUDIE) may be enormous. A public sector steel mill may absorb billions as an "investment," but if it cannot produce steel it has zero value as capital.

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Summary findings

The cost of public investment is not the value of public capital. Unlike for private investors, there is no remotely plausible behavioral model of the government as investor that suggests that every dollar the public sector spends as "investment" creates capital in an economic sense.

This seemingly obvious point has so far been uniformly ignored in the voluminous empirical literature on economic growth, which uses, at best, "cumulated, depreciated investment effort" (CUDIE) to estimate capital stocks.

But in developing countries especially, the difference between investment cumulated at cost and capital value is of primary empirical importance: government investment is half or more of total investment. And perhaps as much as half or more of government investment spending has not created equivalent "capital."

This suggests that nearly everything empirical written in three broad areas is misguided.

First, none of the estimates of the impact of public spending identify the productivity of public capital. Even where public *capital* could be very productive, regressions and evaluations may suggest that public *investment spending* has little impact.

Second, everything currently said about "total factor productivity" in developing countries is deeply suspect, as there is no way empirically to distinguish between low output (or growth) attributable to investments that created no "factors" and low output (or growth) attributable to low (or slow growth in) productivity in using accumulated "factors."

Third, multivariate growth regressions to date have not, in fact, "controlled" for the growth of capital stock, so spurious interpretations have emerged.

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The Tyranny of Concepts: CUDIE (Cumulated, Depreciated, Investment Effort) is *Not* Capital

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The Tyranny of Concepts: CUDIE (Cumulated, Depreciated, Investment Effort) is not Capital [2]

Since I am about to argue that most of what you think you know about an important topic is wrong, let me begin with an old joke, a personal story, and a striking example. The joke: while on a foreign trip a government official of country A was visiting the penthouse apartment of his friend B, a bureaucrat of a poor country. After A admired the fine residence and furnishings he says: "Be honest B, I know that with your official salary you cannot possibly afford this, what gives?" Taking his friend to the window B replies "See that superhighway running through town? 10 percent." Some time later B had the occasion to visit the even poorer country of his friend A and found himself in an even larger and more luxuriously appointed penthouse apartment. Says B, "I know your official salary must be even lower than mine, yet your house is much nicer, what gives?" Taking his friend to the window A pointed out and said "See that superhighway running out into the jungle?" After straining his eyes for a minute B replies "But there is no highway out there." "Exactly," says A with a wink, "100 percent."

While in Tanzania in the early 1990s I traveled to an industrial area which was home to many public enterprises. Most were rotting hulks with little or no workable machinery and with

[2] I would like to thank Bill Easterly, Deon Filmer, Jonah Gelbach, Aart Kray, Ross Levine, Norman Loayza, Allison Morantz, Vikram Nerhu, Moshe Syrquin, Vinaya Swaroop, Mike Walton and the participants at seminars at the World Bank and the Council of Economic Advisors for useful comments and discussions. Dennis Tao' help was very helpful at a critical stage of this project. This paper is different, but draws heavily on, an earlier paper of mine, "Mind your p's and q's: The cost of public investment is not the value of public capital." As for the title, I would like to remind Alwyn Young of the sincerest form of flattery.

the few workers who still bothered to show up standing around listlessly[3]. Later, back in the capital, while discussing the topic of privatization with a high level government official I was told the primary problem was that because these factories had been very costly to construct (financed with large (mostly official) loans) they were very valuable and there were no good prospective buyers as they were too expensive for domestic entrepreneurs to afford and that the government did not want to sell their valuable national assets to foreigners. Clearly in his mind the value of the firms was determined by their historical cost. I tried to convince him that he had *exactly* the opposite problem. *Anybody* could afford those firms, *I* could afford those firms. As ongoing enterprises, with assets and liabilities, the debts incurred to cover construction costs far exceeded the current value of the capital equipment. The real problem was that government couldn't afford to pay people to take them away.

The striking example of two steel mills illustrates this same problem with the valuation of public sector investment. Both mills were built by parastatals with government backing with investments of several billion dollars. One mill, Pohang Iron and Steel in Korea, is now a model of efficiency and a serious competitor in world steel markets. The other, Ajaokuta Steel in Nigeria, has spent upwards of 4 billion dollars and has never been finished to its planned capacity, much less produced to that capacity. In December of 1998, after the end of the previous military government, there emerged reports that US$ 2 *billion* had been siphoned off from the project into the coffers of leaders in the past government.

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[3] We did not visit the worst of the white elephants, the Morogoro shoe factory, as the expatriate manager was reported to be in therapy, depressed from so many visitors trooping through to observe the disaster.

Nearly every estimate of the "capital stock" ever used empirically and certainly all those used in cross national comparisons, including growth regressions, growth decompositions and TFP calculations based on a simple formula:

$$1) \quad K_t = K_{t-1} - \delta * K_{t-1} + I_t$$

This formula, together with an estimate of the "capital stock" in some period allows the construction of a time series of "perpetual inventory capital stocks."

Since national accounting values government investment at cost, if the cost is the same then measured investment is the same whether or not the investment spending was efficient, or even productive. However, the combination of valuation at cost with cumulating investment creates confusion by using one word: "capital", for two completely different concepts. The idea of capital, an accumulated input, not fully exhausted in a single production period, valued for its current and future contribution to output, is a workable and useful concept. The idea of CUDIE, cumulating investment spending over period to an existing total while subtracting off a certain amount as "depreciation", is also a workable and useful concept. However, *equating* the two concepts, or even using one as an empirical proxy for another, requires assertions that are obviously and importantly false. The potential contribution to current and future production of a capital stock is obviously *not* the same as what happened to have been spent on it, especially when governments are the investors. There is *no* plausible positive model of the government as investor that would support associating measured public sector CUDIE with the economic concept of public sector capital.

There are three reasons why this obvious theoretical point might be ignored: the effect is small, the effect is uniform across countries, or there is no alternative. However, the difference

between CUDIE and capital is often empirically large. Moreover, the gap between CUDIE and capital varies widely across countries. Ignoring this gap where government is a small fraction of investment and reasonably effective (e.g. USA) might be acceptable, but when government is the major investor and is ineffective (e.g. Africa, Middle East, Southeast Asian countries) the CUDIE vs. capital gap overwhelms nearly all other aspects of measurement. This lack of theoretical or empirical grounds for equating CUDIE with capital invalidates nearly everything said (a) based on cross national data about the productivity of "public capital", (b) about the decomposition of levels and growth of GDP into "capital" and "productivity", and especially anything about the level or growth of "TFP", and the literature, accumulation versus productivity investigating channels of the impact of growth determinants using decompositions into the proximate causes and the "channels" of growth.

I) Capital and models of investor behavior

Two issues in the measurement of capital affect both public and private capital and I want to get them acknowledged and out of the way quickly before focusing on the distinctive problem with public investment.

First, economics has long made the distinction between the "cost" of a capital good, which is based only on the past, and the "value" of a capital good, which depends only on the future. As early as 1941 Hayek's *The Pure Theory of Capital* should have finally put to rest the idea, "harmful … to the theory of capital" that "that particular capital items represented a definite value, independently of the use that could be made of them, a value which was apparently thought to be determined by the amounts 'invested' in them." (p. 10). The value of

capital and cost of investment will diverge *ex post* for at least three reasons: relative price shifts, technological changes, and mistakes.

Since the value of a capital good depends on expected future prices, not fully anticipated changes in relative prices will change the value of capital goods. These changes in relative prices can stem either from terms of trade changes[4] or from policy reforms. (e.g. a decline in value of capital equipment devoted to import substitution following tariff reductions). Technological innovations create a process of "creative destruction" which reduces the value of existing capital stocks that embody old techniques due to innovation (Jaffee, 1986). Finally, even though private investors equate costs and expected value when investing the private sector often makes (large) mistakes. The private sector will have its share of *ex post* "white elephants" either through underestimating costs or overestimating potential profits.

The second problem that affects both private and public sector capital, especially in cross national comparisons is that differences in the relative prices of investment goods will alter the relationship between investment spending and actual value of capital created (DeLong and Summers, 1993). Some countries have imposed large tariffs on imported capital goods and hence raised the relative price of investment goods. But this additional investment spending over and above international prices does not create any additional productive capital. However, since the Penn World Tables investment series are based on comparable prices of investment

[4] In fact, this may explain the relatively slower growth of the natural resource dependent economies, conditional on their rates of investment (Sachs and Warner, 1995). What looks like slow "TFP" growth using capital stocks based on investment flows may really be that massive investments made by governments in resource extraction industries turned out to have very low returns. One possible way of getting at this phenomena would be to examine the evolution of the stock market valuation of the equity of resource based firms as commodity prices shift. Perhaps this could lead to some useful way to estimate the revaluation of capital impact of terms of trade shifts on Zambia's copper mines or Bolivia's tin mines or Cote d'Ivoire's cocoa plants.

goods across countries then CUDIE based on those series (such as King and Levine, 1993 and Levine, 1999) should at least address, if not solve that issue.

A) The Efficacy of Investment

Having acknowledged the importance of the *ex ante-ex post* distinction and the importance of price differences in the cost of investment versus value of capital in both the private and public sectors, I want to focus on a different distinction, between *accounting* cost of capital of capital good C (X) which is just what happened to be actually spent (suitably deflated and discounted if costs are spread over several periods) and the *economic* cost, EC(X,p). The economic cost is a *technological* concept: the *minimum* achievable cost of creating a capital good with given technologies at relative prices p. Let me define as the *efficacy of investment* the ratio of economic cost to accounting cost.

2) $EC(X)/C(X) = \gamma$

This ratio will vary between 1 (when the minimum cost is achieved) and will approach zero as accounting cost approaches infinity. If a capital good can be replicated (that is it does not involve any special element of rent) the value of a capital good is *at most* its economic cost. Under some additional conditions and assuming a particular form of depreciation[5], this means that the basic accumulation of the capital can be written as in equation 3:

3) $K_t = K_{t-1} - \delta * K_{t-1} + \gamma * I_t$

[5] One factor I am ignoring, so as to not complicate the story line, is that government "depreciation" of assets may be much more rapid than in the private sector. Similar to the cost argument, there are widespread of examples of government not making optimal (or even reasonable) investments in maintenance and hence leading to much more rapid depreciation of assets. See Easterly (1999) for one explanation of the phenomena. This point would only strengthen all the arguments in the paper about the inadequacy of CUDIE as a proxy for capital.

Only a fraction γ of the actual accounting cost of investment passes into the value of capital and equation 1 is a very special, and empirically implausible, case.

The efficacy of investment $\gamma(.)$ which links cost and value is not a fixed parameter, but is the endogenous outcome of a behavioral theory of investors. One cannot assume that investment equals the investment to capital without a behavioral model in which investors see to minimize cost. Under some conditions it is plausible to assume an individual profit maximizing investor will be a cost minimizing investor so that for there is a tendency for γ to approach 1. However even in the private sector there are agency problems. When the creation of the capital good involves specialized knowledge and capital goods are not homogenous then investors may pay much more than the economic cost (think of your last major home improvement). Moreover, in the corporate sector, where management and ownership are separate, managers may not have a full incentive to cost minimize and agency problems within corporations have received a great deal of attention in the literature (Milgrom and Roberts, 1996). But these agency problems in cost minimizing are likely to be especially severe when governments acting as investors.

B) A positive model of government investment efficacy

A behavioral theory of the government as an investor is needed to determine the efficacy of investment which, in turn, is necessary to calculate the capital stock. The model implicitly embedded in all the existing empirical growth literature using CUDIE as a proxy for

capital[6] posits that $\gamma_{i,t} \equiv 1$, $\forall$ i and t: *all* governments are *always* cost minimizing. A model with this prediction could either be derived trivially (that is, just assume it) or by specifying an objective function, powers, and constraints of the government (e.g. omniscient, omnipotent, benevolent welfare maximizer) that would produce this prediction as an outcome. Either way such a model would be obviously false[7]. Not just in investment, but in a wide variety of activities (from health to education to tax collection to policy formation) governments have been shown to be less than fully effective, and more so in some countries than others.

I am not proposing a single alternative model. There is no universally accepted general model of how governments behave, either as investors or otherwise, and for good reason. "Government" behavior is a complex problem of many agents (the citizens or voters) attempting to constrain the actions of one (or relatively few) principals (the leaders) who typically interact amongst themselves in complex ways (e.g. executives vs. legislatures) and these leaders often in turn have only loose control over another set of agents (the government's employees). Each of these problems is only imperfectly understood and is, except in the most simple versions, theoretically intractable. Therefore, I will not attempt to construct a plausible model of government investment, but rather only indicate the features of a class of plausible models might have, and their implications for measuring capital stocks.

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[6] I don't even address the common procedure of using I or I/Y as a proxy for capital stock growth. Not only does this share all of the problems described here with CUDIE, but, as it turns out, I/Y is not even a good proxy for CUDIE growth. As I have shown elsewhere the rate of growth of CUDIE is *uncorrelated* with I/Y in CUDIE constructed from either World Bank (Dhareshwar and Nehru 1993) or Penn World Tables (King and Levine 1994) data. This has the obvious implication that, while I/Y is typically a significant growth regressor and CUDIE growth is typically a significant growth regressor, it is also the case that including both in a growth regression produces almost exactly the same coefficient on both as when they are each included simply. I regard this as something of a puzzle, but certainly the lack of correlation undermines the notion of I/y as a proxy for CUDIE growth.

[7] As a methodological point, this is not because the *assumptions* of such a model might be false, but because the *predictions* are false.

A simple class of agency models of the government as an investor would have several elements[8]. Models would have an actor called G (government) and another set of actors called C (citizens) with G and C endowed with distinct objective functions and beliefs. The objective function of G increases with the gap between actual and economic costs. This could arise in many forms: *venality,* in which G receives direct money payments for personal benefit from the granting investment project contracts (or other government purchases) (Shliefer, 1993, Shliefer and Vishny, 1998); *patronage,* in which G raises costs to provide extra payments to others (either political supporters or employees); *shirking,* in which G does not expend effort (which entails disutility) to reduce costs.

Since the objective function of the agents C is likely to be decreasing in the gap between actual and economic cost, the model would have to have mechanisms whereby C might be able to impose constraints on the behavior of G. Conceptually, these "accountability" mechanisms can be decomposed into the probability of detection, the expected punishment conditional on detection (which is itself a combination of probability of punishment on detection and the magnitude of punishment when detected). The constraints on government behavior are key element, but the most difficult to model convincingly as they vary across countries' institutional and political environments, most obviously between democracies and non-democracies but also in ways that reflects the degrees and types of oversight.

In these agency models G picks the level of actual costs for capital good to maximize its objective function, given its beliefs about the constraints it faces from C. This would lead to a

[8] This version is particularly simply as the complicated agency problem within government is embedded into the actor "G."

model of *actual* costs and a prediction that actual costs would exceed economic costs by the optimally chosen degree (e.g. of venality, patronage, and shirking). For instance, V*(.) is the function that maps from G's objective function and constraints (represented by factors "Z") into the optimally chosen additional costs due to venality, patronage and shirking:

$$4) C^*(x) - EC(p) = V^*(x,Z) + P^*(x,Z) + S^*(x,Z)$$

In a theoretical framework like this, excess costs, γ, would be a function of underlying determinants of both government objectives (e.g. discount rates) and of the control of citizens C over the government agent (e.g. freedom of the press, voter choice, information availability and budget disclosure, judiciary independence and competence, etc[9]). So:

$$\gamma_{i,t} = \gamma^*(Z_{i,t})$$

This is not to argue that government will everywhere and always be inefficient and the private sector always efficient. However, in the context of agency theory there are several considerations that suggest it will be *qualitatively* more difficult for citizens to monitor and control the investment cost behavior of their governments than for shareholders to discipline managers.

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[9] Broadly speaking one could call the control of citizens the "degree of government accountability." This is a common feature of focus on public sector incentives links many current strands of development literature, including: talk of "governance" and "accountability," the treatment of infrastructure in the 1994 World *Development Report* (which focused on the internal organization of infrastructure providers), the talk of "reinventing government" in the USA (Osborne and Gaebler, 1992), discussions of participation as a means of improving public performance (Isham, Narayan, and Pritchett, 1995), estimates of the relationship between returns on investment and civil liberties (Isham, Kaufmann, and Pritchett, 1996) and the work on the features of the public sector in East Asia (Campos and Root, 1996).

First, the state, by (roughly) Webber's definition, exercises the exclusive monopoly on institutionalized coercive power (e.g., police, judiciary and military) within its territory. The state has the ability to extract investible funds irrespective of the citizen's views of the profitability of the capital to be created. This monopoly of violence also implies that the government can often put direct restrictions on the individual citizen's ability to monitor the government, through restricting information, curtailing individuals' ability to complain publicly, etc.[10]

Second, because two entities claiming exclusive coercive power over the same territory usually is a called "war", the state is intrinsically a monopoly. This monopoly makes comparisons of performance on cost or quality difficult without multiple providers of roads, electricity, defense, judiciary.[11] The intrinsic monopoly of government also implies that new start-ups are not a viable mechanism for responding to ineffective states. Unlike giant firms overtaken by entrepreneurs who started small and through superior performance attracted resources that allow them to expand[12], one cannot start a competing "state" in the proverbial garage. Management changes of the state are all or nothing. In the absence of established and respected procedures, these changes frequently occasion the use of force: hostile takeovers of governments tend to be very, very hostile.

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[10] These can lead to variations in performance. Isham, Kaufman, and Pritchett (1995) show that countries with greater civil liberties have higher returns on World Bank financed investment.

[11] Having such multiple providers would itself be an endogenous outcome of the interaction of government and citizens, but an outcome which at least part of "government" can be expected to resist.

[12] These type of evolutionary dynamics are, to my mind, the most convincing argument behind a tendency γ toward 1 in the private sector.

Third, with governments, unlike corporations, "ownership" (the claims to the residual value of assets) is not traded. Again, this makes the agency problem of citizens more difficult. Anyone disgruntled with the management of General Motors or IBM can use an "exit" option and sell her claim to someone else and this provides a useful signal and a mechanism to monitor management performance at creating shareholder value. If there were a market for, say, Nigerian or Nepalese or German citizenship and its price began to plummet because citizenship market analysts thought current management was making poor investments, this would certainly attract existing citizens attention. Also, lack of a citizenship market means that managers of the government cannot be explicitly offered "high powered" incentives linked to economic performance as is frequently the case with top management of corporations[13].

Fourth, many public sector investments are in the public sector because they are "public goods" or, for one reason or another, the capital would not be provided in appropriate amounts by the private sector. The contribution of public sector capital may not be privately appropriable, which implies that, unlike private capital, one cannot look to any actual "market" for roads or schools for a proper valuation of the capital created and hence immediately detect excess costs.

To build a capital stock one needs to impose a value for investment efficacy (γ). To do so requires positive model of government. CUDIE has no priority as a capital stock estimate, but rather is just a very special (and obviously counter factual) case in which $\gamma_{it}=1\ \forall_{i,t}$. The class of

[13] Although (and I recognize this is a footnote that referees will insist I remove) there was a hilarious Saturday Night Live sketch in which a Ross Perot impersonator offered just such a deal, "Hey, economy grows 3 percent I get nothing, but economy grows 4 percent I get 1 billion dollars, now, say the economy grows *five* percent ..."

agency models sketched here would all make two predictions. First, given the nature of states versus firms as investors, positive models would predict that government investment efficacy for many countries would be less than the private sector and much, much less than one ($\gamma_{i,t} << 1$) for many countries. Second, given the range of citizen control over governments in the world, from totalitarian regimes in which questioning government actions leads to prison (or worse) to democracies in which competition for power and public scrutiny are intense and effective, any actual model will predict that, at any point in time, the degree of investment efficacy in some countries will be much higher than in other countries ($\exists$ i,j such that $\gamma_{i,t} >> \gamma_{j,t}$).

C) *Empirical estimates of differences in investment efficacy across countries*

How large are the differences across countries in the efficacy of investment? I present six sources of evidence that these differences are large. The source of evidence are all indirect as the lack of hard evidence is endogenous to an agency approach, as there are very good reasons why governments would make excess costs as difficult to observe as possible.

First, while all countries have white elephants, investments with huge costs and little value, they are more common and more spectacular in some regimes than in others. The Ajaokota is not the only problematic still mill, the Lazaro Cardenas mill in Mexico has similar problems with cost over runs. A nuclear power plant constructed in the Philippines under Marcos cost, as an investment, more than 2 billion dollars but was never commissioned and so has zero value as capital. The Morogoro Shoe factory in Tanzania cost $40 million (financed by The World Bank), its peak capacity utilization was never more than 4 percent, and is now a mostly worthless hulk (World Bank, 1991). The list could go on and on. In contrast, some other

countries, both developed and developing, have reasonably effective investments and few such tales.

Second, there are even more spectacular (but even less substantiated) reports of leaders and their cronies siphoning off, in one form or another, fortunes that are a significant fraction of their country's total investment. Much of those funds appeared as "investments". In other countries, the wealth of government officials is quite closely monitored, and at least does not become expressed as a proportion of GDP.

Third, a quantitative piece of evidence about differential public sector effectiveness in investment is the cross national data on *ex post* economic rates of return on World Bank financed investment projects[14]. The World Bank finances, but does not implement, government projects in many countries with the same procedures and staff in every country, hence there are good reasons to believe the differences in returns across countries indicates varying *government* investment efficacy. Table 1 lists the summary statistics on returns over 1973-1991 and provides some anonymous country examples. The mean return of across all those countries with nine or more projects was 14.1 percent but with a range from 0 to 25 percent. In one African country the World Bank lent nearly a billion dollars over this period to finance 31 projects which achieved a median rate of return of *zero*. In contrast the $8.2 billion lent to finance government projects in one East Asia country earned a median return of 19.5 percent. While there clearly are huge differences in the efficacy of governments in implementing investment projects, this evidence

[14] The *ex post* return is assessed after disbursement of the World Bank loan. Also, these are *economic*, not financial returns to investment, so that they do, at least in theory, value non-marketed outputs, e.g. roads.

cannot distinguish the causes of the differences in investment returns (between excess costs, inefficient operation, or poorly chosen design).

Table 1: Economic rates of return on government investment projects financed by the World Bank.

	Number of projects	Cumulative investment (millions)	Median *ex post* economic rate of return
An African country	31	915	0
A South Asian country	88	19,718	16.5
An East Asian country	41	8,233	19.5
All countries			14.1

Source: OED database.

Fourth, Table 2 reports the dollar cost per kilometer of similar road construction (in 1985$) in various countries as taken from various World Bank project documents. While some large fraction of the differences in costs is likely accounted for by technical differences (like the location of the road) some of these differences in cost likely reflect differences in government effectiveness. These reported differences, of an order of magnitude, seem too large to be entirely be due to differences in government efficacy.

Table 2: Costs of construction of a kilometer of similar road in selected countries (in 1985$)			
Country	High Cost countries	Country	Low Cost countries
Honduras	771,068	Chile	143840
Ethiopia	721,160	India	143306
Guatemala	631,965	Costa Rica	131966
El Salvador	540,632	Philippines	111343
Pakistan	434,650	Uruguay	95440
Nigeria	426,839	Korea	92072
		Sri Lanka	65277
Average cost: 287,350. Source: Canning and Fay, 1995. Notes: Brazil and Argentina were not included in the high and low list because of doubts about appropriate deflation and exchange rate conversion under hyperinflation.			

Fifth, the counter-part of CUDIE at the firm level is the inflation adjusted, economically depreciated, cumulative investments in the firm. This suggests that a good indicator of public sector investment efficacy is to compare what public enterprises (producing private goods in a competitive environment) would sell for relative to their CUDIE[15]. In particular, this is a critical thought experiment for distinguishing the "no capital" from the "badly used capital" explanations of the low output from public investments. If the reason for low output from public capital is simply low productivity under public sector management, then public firms could sell for near their CUDIE (and perhaps much more than their annualized current profit stream)16. If, on the other hand, the investment spending has not produced economically valuable assets then privatization values will be perhaps much less than CUDIE.

[15] The two qualifications in the sentences are important: "private good" so that prices really could be charged and "competitive environment" because many of the most lucrative privatizations are those that sell monopolies, like telecommunications firms, where the price paid for accumulated assets is difficult to disentangle from the price paid for the exclusive franchise.

[16] Although there is not certain as the assets themselves may be in declining industry and there might be discounts due to asset specificity.

However, in spite of the spate of privatizations over the last decade, this remains largely a thought experiment. I have not been able to collect any systematic concrete information of this type[17]. However, the total net revenues of the unit created to undertake the privatizations of East German assets was *negative* $200 billion, the negative receipts obviously indicate other factors, such as that new owners had to absorb obligations, but nevertheless indicates little underlying capital value (Boycko, Shliefer, and Vishny, 1993). While many developed countries and Latin American countries have derived substantial revenues from privatization efforts in many African countries the "privatizations" have been mainly liquidations and have generated very little net revenue.

Sixth, there are an increasing number of surveys comparing costs of doing business and bureaucratic quality across countries. The first generation were based on commercial services rankings (as used in Mauro 1998, and Keefer and Knack 1997). There is now a new generation based on comparable firm level surveys recording the level of various costs incurred (Kaufmann, 1998, Charap and Harm, 1998). These differences would translate into higher reported costs of investment and greater ineffectiveness in creating capital.

The conceptual distinction between public sector CUDIE and the value of public capital is perfectly obvious. It is also obvious that there is no general positive behavioral theory of government behavior that would justify a universal prediction of cost minimization. Finally, that the efficacy of investment varies widely across countries and has often been quite low is also perfectly obvious. The key question is whether these perfectly obvious points are fruitful and

[17] It would be naive to be "surprised," as for governments to admit they are selling firms for a fraction of what they paid for them is obviously embarrassing, and hence best left undocumented. But all the more reason it would have a high payoff to document.

empirically important. The next two sections address this question, first, for public sector capital and the next for cross national examination of "productivity" and growth determinates.

II) Productivity of public capital and policy recommendations

How productive is public capital? Is there too much or too little? Is there too much of one type and not enough of another? Many types of public capital do not produce private goods, but contribute to production indirectly through reductions in costs or increases in productivity of private production. Often it is impossible to value public capital through a "market". An aggregated approach if often the only way to estimate the impact of some types of public sector capital; many empirical studies have used cross national data on public sector investment spending to examine whether, and what types, of government spending are "productive". However, this approach may often falsely conclude that "public capital" is unproductive when in fact public capital would be very productive but the investment efficacy is low.

A) A basic production function with public sector capital

Start with a simple one good (Y) production function specification that distinguishes private, K_p, and public, (K_g "g" for "government") capital stocks and allows for a separate productivity parameter for public (A_g) and private (A) production. What enters the production function is public capital (the true stock of capital available) and also how well that stock is used (A_g) to produce a flow of "public capital services"

$$7)\ Y = F(A, K_p^{\alpha_p}, K_g^{\alpha_g}, A_g)$$

Now suppose that only a fraction $\gamma(.)$ of public investment actually creates useful public capital (the equation should also reflect that depreciation is also a behavioral, not technological,

parameter but, again, I leave this aside). Then the capital stock growth is:

$$8)\ \hat{K}_g = \gamma(.)*(I_g/Y)*(Y/K_g) - \delta_g$$

When this definition of capital growth is substituted into a linearized (e.g. quasi-Solow[18]) expression for growth rates of output, the coefficient on public investment in the growth equation is the product of the production function parameter (α_g) and the efficacy of investment coefficient $\gamma_g(\ )$ and the inverse of the capital/output ratio (κ_g). Alternatively, the coefficient on CUDIE growth is $\alpha_g*\gamma(.)$:

$$9)\ \hat{y} = \alpha_g*(\gamma(.)*\frac{I_g}{Y}*\kappa_g - \delta_g) + \alpha_p*(_p*\frac{I_p}{Y}*\kappa_p - \delta_p) + \hat{A} + \hat{A}_g$$

A growth regression (or any other empirical procedure) that was limited to observing outputs and investment inputs (either as an investment share of GDP or as CUDIE) cannot separately identify the two effects of the technological production function parameter, α_g, the productivity of public capital and the endogenously determined public sector efficacy of investment, γ (.). This is not merely a problem of *bias* in the estimate of the productivity of public capital (α_g) but of *identification.* Neither time series or cross unit regressions based on equation 9 estimate the parameter α_g *at all.* Even if γ were fixed (over time or across unit of observation) the coefficient CUDIE from a growth regression is a (perhaps biased) estimate of $\gamma*\alpha_g$.[19]

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[18] Using a "Solow" type production function for the example, hopefully does not create confusion that this is about "new" versus "old" growth issue or a "spillovers" versus "direct productivity" issue or anything other issue about the assumed production function. One way or another "public capital" will enter the production function and this is *not* about how Kg enters the production function, but about the fact Kg is badly measured.

[19] Using investment shares, one needs to divide by the capital/output ratio to recover the production function parameter, but the same lack of identification applies.

But γ is not constant either over time or across countries. Assume there were a universal positive model of investment efficacy and, say for simplicity, it was determined completely by some variables Z and those were included linearly in the growth equation. It would still be the case that the regression of growth on investment recovers, at best, $\bar{\gamma}(z)^* \alpha_g$ (the output effect of investment evaluated at average efficacy) but not α_g. Merely inserting Z (e.g. "extent of corruption" or "quality of bureaucracy" or some additional variables thought to be related to government efficacy) into the linear growth regression does not solve the identification problem. A linear regression of growth on public investment and efficacy (and whatever other terms) does not recover an estimate of the productivity impact of public capital would still have the interactive effect specified to be correctly measured.

B) Growth regressions with public CUDIE and their interpretation

The empirical implications of an investment efficacy that was significantly less than one and which varied widely across countries would be that, first, we would expect the coefficient on investment or on public CUDIE to be lower than that of the private sector either in cross sections or in individual countries. Second, we would expect the estimated impact of public CUDIE to vary widely across countries.

Turning to the first hypothesis, we specify two typical growth regressions, one of which is a simple growth accounting exercise that regresses growth on (potentially endogenous)

investment rates and another of which adds policy control variables[20]. If we *assume* that public capital's share in output is proportional to its share in total investment then we can use the estimated coefficient to infer the average relative effectiveness of public investment;

$$10)\frac{\gamma_g}{\gamma_p}=\frac{\beta_g/\alpha_g}{\beta_p/\alpha_p}$$

The estimates derived from this approach reported in table 3, indicate a *relative* efficacy of public investment versus private investment of 50 to 60 percent. The usual interpretation that this represents lower returns on public investment. But this same evidence consistent with not that there are lower returns to public capital once created, but that there is a much lower government than private investment efficacy in this sample so a given amount of investment creates less capital. But the main point is that from the regression coefficients (α_s) one can make assumptions about γ's to make inferences about the α's or vice versa, but some *assumptions* must be made as the regression coefficients alone do not identify either.

[20] Hulten (1996) does similar regressions within the context of a extended Solow model in which the coefficients on public and private investment are treated as production function parameters. His paper however treats only limited infrastructure items and does not make the general point about identification of investment efficacy in the government sector, nor the implications for measured TFP.

Table 3: Cross national growth regressions with public and private investment separately		
	Without "policy" variables	With "policy" variables
Private Investment {average share I_p/Y}	22.3 (6.41) {10.9}	22.3 (6.29) {11.0}
Consolidated public sector investment {average share I_g/Y}	11.5 (2.82) {8.9}	9.35 (2.09) {8.9}
Implied relative effectiveness of public capital[a]	.63	.51
Other variables in the regressions:		
Ln Initial Income	-0.42 (1.17)	-.82 (2.25)
Primary Enrollment rate	-.19 (.20)	1.0 (1.03)
Secondary Enrollment rate	2.0 (1.49)	.3 (.203)
Dummy for 1960s	3.1 (5.78)	2.49 (4.32)
Dummy for 1970s	2.3 (6.08)	2.1 (5.97)
Dummy for Sub-Saharan Africa	-1.2 (2.42)	-1.5 (2.90)
Dummy for LAC	-1.6 (3.54)	-1.68 (3.53)
Ratio M2/GDP		2.2 (2.01)
Government Consumption/GDP		-8.4 (2.41)
N (obs)	162	136
Adjusted R2	.485	.551

Note: Data is taken from Easterly and Rebelo, 1993. t. statistic in parenthesis. Constants are included but not reported.
a) This is the ratio of the ratios of the regression coefficient on investment over the average share of investment in GDP for public and private.

Similar evidence on returns between public and private sector investment, but limited to a single country, is the difference in returns to investments in manufacturing in the public versus private sector in India. Rajaiah (1989) compares the returns on capital employed in private and public enterprises and finds that over the 1967/68 to 1973/74 period for which comparable data are available, the returns are 4.2 in the public and 24.9 in the private sector. Even if one limits attention to "goods producing" public sector firms (to account for the possibly non-commercial nature of many public firms), the average return on capital employed is still only 3.9 percent. Joshi and Little (1994) use an alternative, indirect, calculation using the relationship between growth rates, investment rates, and capital shares to calculate the returns to investment in some sectors in India over the periods 1960-1975 and 1976-1986. As shown in table 4, they find the return to investment in public sector manufacturing in the latter period was 5.2 percent while the return in private sector manufacturing was more than four times higher, at 22.6 percent. Again, this evidence cannot distinguish among various explanations of lower public sector impact (e.g. excess costs, excess depreciation, inefficient operation) or a low marginal product of additional public capital but is consistent with much lower government than private investment efficacy ($\gamma_g << \gamma_p$).

Table 4: Alternative calculations of the returns to investment in public and private sectors in India.							
	Return on capital employed from firm accounts (Rajaiah)			Inferred from contribution to growth (Joshi and Little, 1994)			
Period:	Goods producing public enterprises	Private sector	Ratio Private/ Public	Whole public sector	Manufacturing		
					Public	Private	Ratio private/ public
1960s and 70s	3.9	24.9	6.4	5.4	2.1	11.1	5.3
1976-86				6.2	5.2	22.6	4.3
Source: Rajaiah (1989) from table 3.5 and tables 6.1 to 6.10. Joshi and Little (1994), table 13.4, estimates based on adjusted labor quality.							

If governments differed in the efficacy of their investments one would expect the estimates of the impact of public CUDIE to be very different for different countries. Unfortunately there are few good estimates of the productivity of public capital and what few there are, are of limited comparability[21]. But what few studies that there are do show huge differences across economies. Estimates of the returns to public capital in Mexico are between 5 and 7 percent (versus 14 to 18 for private capital) (Shah, 1992) while estimates from two East Asian economies in which γ is thought to be high are 77 percent in Taiwan (China) and 51 percent in Korea (Uchimura and Gao, 1993). One could either interpret such differences as extremely large differences in productivity across countries (perhaps public capital in Mexico

[21] I'll ignore the whole literature in the USA and the debate between Aschauer (1989), who finds returns around 60 percent and Holtz-Eakin (1992) who finds returns around 0.

has a very low marginal product) but one can equally legitimately interpret these differences as reflecting differences in the efficacy of public sector investment (γ_g) between the countries.

Since nearly all of the previous empirical literature on productivity of public capital has relied either on expenditures or cumulative investment flows to estimate capital stocks this critique leads to fundamentally different interpretations of the results.[22] Rather than drawing inferences from estimates about the effect of public capital (or the optimal effect of any kind of expenditure) as if one were recovering estimates of a "production function" it is equally (or perhaps more) plausible that empirical results reflect differences in investment efficacy across countries, especially when countries with extremely different types of governments are included in the same analysis.

C) Sensible policy advice on investment in the public sector

From an empirical finding that the impact of public CUDIE on output was small, one might be tempted to recommend that the public sector should invest less since the productivity of public "capital" is low. But this is obviously wrong, in two senses. The first and most obvious point is that policy recommendations clearly must differ across countries (and time). An empirical finding that "public investment" is not related to performance can either mean that (a) countries have over-invested in public capital so its marginal product (α_g) is very low *or* (b) that public capital is very productive but that the average effectiveness of public investment in creating public capital (γ) is very low *or* (c) that public capital has been created effectively but

[22] Exceptions are Canning and Fay (1996) and Hulten (1996) which attempt to estimate infrastructure productivity using data on actual stock (e.g. phone lines, miles of road), although even here, do they recognize, one must adjust for quality and actual *usable* stock.

used badly (low A_g) *or* (d) any combination of the three. Cross national regressions recover, at best, some "typical" γ_g* α_g but the true γ_i or α_i for a given country could be much higher or lower. Examining cross national regressions and recommending that Chile or Korea not build roads because the observed productivity of public CUDIE in roads is low in a sample that includes Tanzania or Myanmar is clearly wrong.

Second, imagine the decision tree for an economist (acting altruistically with a benign social welfare function as the objective function) who asks: "Should I recommend spending Y dollars of public sector resources to create capital good X?" The first question is whether X is in a sector where there is some rationale for investment from the public sector. If the answer is no, stop. The next question is, even if there is a scope for public sector intervention, whether the appropriate solution is direct provision or regulatory or some type of publicly subsidized procurement. This is an analytically difficult (and hence often ignored) question as the answer will vary form country to country and sector to sector. If direct provision is appropriate, the next question is whether the present efficacy of spending Y dollars to create capital would be high or low? If the roads or education or irrigation ministry is completely corrupt or ineffective (low γ), then prior to the investment decision is the question, "whether there are reforms capable of increasing efficacy?" If there are reforms that would alter incentives so as to raise γ, then perhaps those should be pursued first before expanding investment.

Only after addressing all these questions does one arrive at the question of whether the marginal product of additional public sector capital is high enough to justify additional investment in the capital good X. If public sector investment efficacy is abysmally low ($\gamma \equiv 0$) with no prospect for reform then even if the marginal product of additional public capital would

be very, very high[23] our hypothetical economist might still recommend no investment spending. Conversely, if public sector efficacy is high ($\gamma \equiv 1$) then a much lower productivity of public capital could justify the investment.[24]

III) Existing growth decompositions are wrong

There is a powerful institution behind decomposing output per worker into past part "due to" how much "stuff" each worker uses and how well that "stuff" is used. Of course, how exactly to define "stuff" and "due to" in a production function is the subject of much growth literature debate. But, no matter how the production function is specified, this approach goes empirically badly wrong when the countries compared differ either in the importance of public sector in total investment or in the efficacy of that public investment as then "stuff" is badly measured.

Suppose one is comparing the output per worker of Tanzania and the United States. In 1985 relative outputs (in purchasing power adjusted units, P$) were 35 to one while CUDIE stocks were only 38 to one. If one plugs this into a simple $y=Af(K)$ production function model then one can begin to ask questions like, "are the differences in A implied reasonable?" or "How high would α need to be if A were the same?" and "What about other dimensions, like human capital?", and so forth. However, for the USA CUDIE is likely a reasonably good estimate of

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[23] The case of low efficacy is common in the developing countries reconciles a common paradox. For decades development "experts" have observed the lack of roads, power, schools, health clinics, and assumed that since the stock was so low, the marginal product of public sector capital must be high, hence "more investment" was the appropriate answer. However, this has left a legacy in the poorest countries of large amounts of public sector investment (often with official financing) but with little or no public sector capital to show for it.

[24] This also re-enforces the point made by Easterly (1997) that the continued common use of "ICORs" as a measure of "efficiency" and "investment" as a causally driving force to growth is absurd and should be stopped.

capital but CUDIE almost certainly dramatically overstates available capital in Tanzania. Therefore, no matter how complex the equations involving "K" get, this whole line of reasoning fails empirically because K is badly measured by CUDIE. The decomposition of output into "stuff" (factors) and "using stuff well" (productivity) only works if at least one of the two can be measured well independently.

A) Estimates of TFP

This obviously affects conventionally measured TFP growth. Over the last 30 years, fifty-five percent of developing countries have measured TFP growth less than zero, with more than a quarter showing TFP lower than *negative* one percent per annum. One could argue that over time these countries were getting less and less productive in using *existing* factors. A different interpretation is that much of the "factor" accumulation measured by CUDIE is false. CUDIE *over*states capital and hence understates TFP[25].

This empirical reinterpretation can be explored by following a simple three step procedure (data and procedures are documented in the working paper version appendices, available on request). First, calculate the growth of conventional TFP country by country using reasonable shares for physical and human capital and observed CUDIE growth for both. Second, assume that the minimum TFP growth rate is available to any given economy in the world. I use

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[25] As mentioned above DeLong and Summers (1993) emphasize differences across countries in the price of investment goods as an important source of mis-measurement of capital stocks. If prices are higher in India than in Korea then a greater investment rate (in nominal terms) is required to produce an equivalent increment to the real capital stock. The capital stocks used in the base case are calculated with investment rates that use the investment deflation based on international comparisons of prices so this effect is already incorporated.

either zero[26] or one percent per annum (the average in the OECD). In some cases this assumption about TFP is inconsistent with the observed growth of CUDIE and output, that is, CUDIE growth is "too high." Therefore, the third step is to scale back CUDIE growth to be consistent with the observed rate of growth of output and the assumed growth of TFP. This scaled down CUDIE growth creates what I call the "implied" rate of factor accumulation.

In equations, where $\tilde{k}$ and $\tilde{y}$ are the observed percent per per annum growth of per worker CUDIE and output, the implied rate of factor accumulation ($\hat{k}$) is:

$$\hat{k} = \begin{array}{l} \hat{k} = \tilde{k} \ \ if\ TFP \geq TFP_{\min} \\ \hat{k} = \tilde{y} \ \ if\ TFP < TFP_{\min} \end{array}$$

For each of the two assumptions about "minimum" TFP growth (0 or 1 percent) I carry out three variants on this calculation. The first scales back both physical and human CUDIE equally. The second assumes that human CUDIE should not be scaled back and scales back just the rate of growth physical CUDIE (even though the contribution human CUDIE is still used in calculating TFP). The third just assumes away human capital growth entirely (in both the TFP calculation and the re-scaling).

I am not able, for these large samples, to scale back differentially government and private investment as there are not widely available series on the extent of investment in the "consolidated public sector." Therefore I scale back private and public CUDIE equally, which, if private investment efficacy is higher, creates very loose upper bound on the investment efficacy in the public sector. Second, this exercise cannot distinguish among possible

[26] Zero is an obvious lower bound as Bernard 1999 points out steady state TFP cannot be negative.

explanations of deviations of "capital" from CUDIE (shifts due to price changes, excess depreciation, etc.) as all are present to some degree.

The results in table 5 are striking in a number of ways. First, the results suggest that in many regions the "implied" rate of factor accumulation was very, *very* much slower than the standard CUDIE estimates would suggest. In every developing region (except for East and "other" Asia) the implied rate of "capital" growth was only *half* (South Asia, Africa, MENA) to *three quarters* (Latin America) as large as CUDIE growth even when TFP growth was assumed to be zero. If TFP the growth "available" was one percent, implied capital growth was a *quarter* or less of CUDIE outside of East Asia and the OECD.

Second, the results in table 5 are striking in that they accord with my intuition of the effectiveness of public investment across countries.[27] In the OECD and the High Performing Asian Economies (HPAE) there is very little difference, consistent with casual empiricism of reasonably effective public sectors, in which, although there was perhaps pervasive corruption, at least things got done. The problems appear to be worse in regions where the fraction of investment that was public was high and, one suspected, efficacy low: the Middle East where governments invested huge oil revenues (even though the subsequent terms of trade shock on these economies and requisite capital revaluation must be factored in); Sub-Saharan Africa (where Collier 1999 has recently documented the low returns to investments); and South Asia.

Third, it is also striking that there is no relationship between CUDIE growth and the ratio of "implied" capital growth to CUDIE (the cross country correlation is only -.19). Africa had

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[27] See Bosworth, Collins, and Chen (1995) for an excellent discussion and implementation of the various issues involved in this type of "growth accounting" estimate of TFP. The regional pattern of their preferred TFP estimates (in spite of the different data, regional coverage, and time period) are similar to the TFP reported in table 5, SSA -.7, MENA -.4, LAC .1, OECD 1.0, East Asia .8, South Asia .7.

both low investment effort (2% p.a) and translated only a small fraction (49%) of that investment into "capital." In the MENA region there was no shortage of investment and CUDIE growth was nearly as large as in the HPAE (3.5% vs. 3.8%), but growth of "implied" capital was quite slow (1.6%).

Table 5: Results of calculations of CUDIE growth and "implied" factor accumulation with imposed minimum rates of TFP growth, regional averages

Region (number of countries)	CUDIE growth (% p.a.)	"observed" TFP	CUDIE growth "Implied" if TFP growth=0	Ratio of "TFP Implied" to Observed CUDIE growth	CUDIE Growth "Implied" if TFP growth = 1% p.a.	Ratio of "TFP Implied" to Observed CUDIE growth
Middle East, North Africa (9)	3.53	-1.3	1.62	45.8%	0.95	26.9%
Sub-Saharan Africa (21)	2.03	-0.6	0.99	48.8%	0.17	8.4%
South Asia (6)	2.13	-0.9	1.15	54.0%	0.19	8.9%
Latin America and Caribbean (23)	1.69	-0.1	1.22	72.2%	0.41	24.3%
High Performing Asian Economies (7)	3.84	1.2	3.63	94.5%	3.07	79.9%
Other Asian Economies (4)	1.64	0.3	1.56	95.1%	0.82	50.0%
OECD (24)	1.79	1	1.75	97.8%	1.32	73.7%

Source: Author's calculations.

Table 6 shows that variants on this calculation give different quantitative results, but the three basic results are robust. If one subtracts from output growth an attribution "due to" human capital growth in deriving TFP but only assumes that physical CUDIE growth should be scaled back, the results are obviously even more dramatic, with regions like MENA, SSA and South Asia showing *zero* growth contribution of physical capital accumulation over the period. On the other hand, if one assumes that human capital accumulation had *no* effect on output (which is

what the aggregate growth regressions suggest, Benhabib and Spiegel 1994, Pritchett 1996, Islam 1995) and use only physical CUDIE in creating TFP and then scale back just the physical CUDIE, the results are obviously less dramatic: Nevertheless in both cases most of the regional patterns are preserved. The only exception is South Asia, which looks very effective in physical capital *only if* human capital is assumed to have *no* impact.

Table 6: Results of calculations of actual and "implied" factor accumulation, regional averages

Region	# of countries	Adjustment of just the physical capital stock with educational capital in the TFP calculation			Adjustment of just physical capital without education capital in the TFP calculation		
		Percent per annum growth		Implied /Observed	Percent per annum growth		Implied /Observed
		Observed CUDIE	Implied "Capital"		Observed CUDIE	Implied "Capital"	
Middle East, North Africa	9	1.9	0	0.0%	1.58	0.5	36.7%
Sub-Saharan Africa	21	0.85	-0.19	Negative	0.7	0.45	64.2%
South Asia	6	0.92	-0.05	Negative	0.76	0.73	96.0%
Latin America and Caribbean	23	1.08	0.61	56.5%	0.89	0.7	78.6%
High Performing Asian Economies	7	3.03	2.82	93.1%	2.5	2.5	100.0%
Other Asian Economies	4	1.19	1.09	91.6%	0.98	0.98	100.0%
OECD	24	1.36	1.32	97.1%	1.12	1.11	99.1%

My conjecture is that the difference between CUDIE growth and the "implied" capital growth is at least in part due to difference in γ, which are in turn determined by difference in constraints governments face from their citizens. Recently Sachs and Warner (1995) have proposed an indicator of overall policy that combines a binary indicator of whether or not a government is "repressive" and a binary indicator of a minimum amount of "openness" (non-repressive and open governments are classified as having an "acceptable" policy environment).

Table 7 shows the difference in the CUDIE versus implied capital stock growth by whether regimes were politically repressive. Average CUDIE growth was almost identical (2.14 vs. 2.18). However, the "implied" rate of factor accumulation is 86 percent of CUDIE for the politically non-repressive economies but only 50 percent for the repressive governments. Moreover, not only is the difference between observed and "implied" lower, suggesting on average lower efficacy in regressive regimes, but the *variance* of the difference is much higher for repressive regimes (1.9 vs. .64)[28]. So while some repressive regimes might be quite effective at creating capital, others are very, *very* ineffective. The evidence is suggestive that the problem of low returns on investment is related to issues of governance, in the broad sense of government efficacy, not just economic policy.

Table 7: Ratio of observed to implied factor accumulation, across types of countries.

Country classification	# of countries	Percent per annum growth factor accumulation		Ratio	Standard deviation of the difference
		Observed	Implied		
Non-repressive	56	2.14	1.84	86.0%	0.69
Repressive	38	2.18	1.08	49.5%	1.9
Acceptable policies	28	2.27	2.15	94.7%	0.46
Bad policies	66	2.1	1.27	60.5%	1.56

Sources: Sachs and Warner, 1995 for classification of countries.

[28] The difference between repressive and non-repressive is robust whether one excludes Africa (mostly classified as repressive) or the OECD all (non-repressive) from the calculations.

These calculations are not "proof" that CUDIE does not measure capital, it simply demonstrates the implications of reversing the interpretation of slow growth from "low TFP in spite of capital accumulation" to "mis-measured capital accumulation." In spite of the fact that nearly all previous TFP calculations have taken CUDIE as estimates of capital at face value, there are no logical, theoretical or empirical grounds on which to do so. Except in circumstances one is willing to make the false assumption that both the public sector and private sector are equally and fully effective in creating capital from investments[29] the existing literature says *nothing* about a decomposition between "factors" and "productivity" as perpetual inventory methods do not create an estimate of available productive capital. Moreover, the discrepancy is not uniform but will be large for some countries (e.g. Tanzania) and small for others (e.g. USA, Germany).

The ubiquity of this logical inconsistency is well illustrated by the recent paper of Hall and Jones (1999), two of the world's premier macroeconomists. In their paper they postulate that "social infrastructure," which is measured by elements of government performance (e.g. corruption) and policies (especially "openness") affects output per worker. They then decompose output into "capital" and "productivity" using perpetual inventory capital stocks. Using this capital stock they show the proportions of output differences due to various sources (their table 1) and even illustrate the channels where which decomposes the effect of "social infrastructure" into its impact on "capital" and its impact on "productivity" (lnA). However, it is

[29] In addition of course to assuming away of relative price shift induced revaluations, mistakes, terms of trade changes, obsolesce, excess depreciation

logically inconsistent to postulate that these characteristics of governments affect output, given capital stocks, but do not affect the output of capital goods for a given amount of investment.

C) Growth regressions (again) channels of growth

As a final implication, the fact that CUDIE differs from capital systematically across countries implies two things about growth regressions.

First, having controlled for CUDIE is not the same as controlling for capital and the "omitted variables bias" affects all other growth regression coefficients. The deviation of actual capital from CUDIE is country (and time) specific and is endogenously determined and hence is unlikely to be orthogonal to other co-variates. Take a regression of growth (y) on CUDIE (c) and some other potential growth determinant, X. The regression is:

$$y_i = \alpha\bar{\gamma} * c_i + \beta * X_i + \varepsilon_i$$

However, since the cross national regressions almost invariably impose constant coefficients this means that the error term will contain an "omitted variable" for varying efficacy:

$$\varepsilon_i = \upsilon_i + [\gamma_i - \gamma] * c_i$$

As usual the direction of the "omitted variable" bias will be difficult to sign in a multivariate context, but will depend on the correlation between the included variable (x) and the omitted variable. The only correct interpretation of such regressions is: "impact of variable X conditional on CUDIE " not the "impact of variable X conditional on capital stock growth."

Second, this inability to estimate factor growth also implies that all attempts to empirically decompose a variables impact on growth into its "factor accumulation" effects and its "productivity" effects is doomed from the outset. In investigations of the channels of impact,

researchers should be clear that what is estimated is the "impact of X on growth *via* investment effort or CUDIE" and the "impact of X on growth, *conditional on* investment effort or CUDIE." This would again make it clear that the decomposition is not into what is normally conceived of as the concepts of "capital" and "TFP" but into "CUDIE" and a residual also contains a term determined by the efficacy of investment (as well as revaluation, etc.).

To some extent this is reassuring, relative to the previous interpretations of the residual actually reflecting TFP. In many cases researchers regressed the residual of a growth regression (or a constructed TFP using imposed factor shares) on underlying "determinants" of TFP. However, as Hall (1989) pointed out, strictly speaking, within the Solow growth model TFP should be orthogonal to all kinds of rhs variables representing "incentives" as since factor payments exhaust product there should be no opportunity for incentives to affect TFP. However, if the residual is correctly interpreted as reflecting (a) technical progress (fundamental progress in knowledge) *and* (b) changes in efficiency with which capital stocks (human and physical) are used *and* (c) the efficacy of past investments in creating capital useful for current period production then it need not be orthogonal. In this light many of the existing "TFP" results are more easily understood.

Conclusion

I would propose that we economists end the tyrannical reign of confusion caused by using the same word for two distinct concepts. Lets call capital, capital and CUDIE, CUDIE.

All of the recent spate of empirical research on growth using investment or capital has implicitly assumed that *all* governments everywhere were *always* cost minimizing investors.

This is obviously false. Cross national empirical research using investment rates or CUDIE cannot be used to make statements such as "the estimated impact of public capital is...." or "the contribution of output due to capital is..." or "the portion of output growth not accounted for by differences in factor accumulation is..." This is not an arcane quibble, but is empirically important and has serious policy and theoretical implications. If one concludes that the "productivity of public capital is low" this has different implications for government investment policy that "the output impact of CUDIE is low." When stated correctly, it is apparent the impact of CUDIE might have been low because of low investment efficacy, because of inadequate maintenance and hence high depreciation, because of larger *ex post* shifts in relative prices, or because of poor efficiency of the operation of capital in the public sector. Each of these has different policy implications than low productivity of public capital. The fact recorded government investment spending of various types may or may not be associated with better economic performance is an interesting fact but by itself provides little useful information for policy recommendations.

Similarly, if one concludes "capital does not account for a large fraction of cross national output differences" this suggests certain theoretical directions, e.g. research into differences in "technical progress" or "technological diffusion" or "efficiency." If however, the actual empirical result is stated more prosaically, and more accurately, as "differences in what governments run by corrupt autocrats/oligarchs/regimes spent in the past and was recorded as investment does not explain current output" this suggests very different lines of research, approaches which are much more likely to be fruitful in understanding cross national differences in output growth.

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